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Transition Economics Series

A Comparative Analysis of the Czech Republic and Hungary

Using Small Continuous-Time Macroeconometric Models

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Abstract

In this paper we estimate a continuous-time macroeconometric model of the Hungarian economy and compare it with the Czech model described in Stavrev (1998). On the basis of the estimated models we provide simulations and compare the results between the two countries for i) anti-inflationary policy; ii) monetary and fiscal policies; iii) the effect of different wage indexation schemes; iv) the effect of nominal wage rigidities and v) the effect of price and nominal wage freeze.

Keywords
Lucas critique, policy simulations, macroeconometric model, anti-inflationary policy, effectiveness of monetary and fiscal policies

JEL Classifications
C51, C52, C53, E17, E50, E52

Comments

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Contents

1. Introduction

The aim of this paper, on the basis of estimated macroeconometric models for the Czech Republic and Hungary, is to compare different policy simulations for the two countries in transitions. In particular we are interested in anti-inflationary policy, the mix of fiscal and monetary policies and exchange rate policy.

We have chosen the Czech Republic and Hungary because of several similarities with respect to their period of transition to a market economy. Both countries experienced a period of initial fall of the real GDP in the early nineties and resumed real GDP growth in 1994. Some of the main macroeconomic indicators for the two economies are given in Table 1 below.

Table 1: Main Macroeconomic Indicators for the Czech Republic and Hungary

	year	1991	1992	1993	1994	1995	1996	1997	1998
Czech R. 1)	% real GDP [i]	-14.2	-6.4	-0.9	2.6	6.4	3.9	1	-2.8 [x]
2)	inflation [ii]	56.6	11.1	20.8	10	9.1	8.8	8.5	6.8
3)	% nom. wage [iii]	15.4	22.5	24.5	16.6	17.7	17.6	11.6	9.0
4)	% CA of GDP [iv]	n.a.	n.a.	1.3	-2	-2.7	-7.6	-6.1	-1.4 [x]
5)	% unemployment	4.1	2.6	3.5	3.2	4.1	3.8	4.7	7.5
Hungary 1)	% real GDP	-11.9	-4.3	-2.3	2	1.5	1.3	4.4	4.5 [x]
2)	inflation	35	23	22.5	18.8	28.2	23.6	18.3	15.5
3)	% nom. wage	30	26	18.6	25.8	16	18.2	23.2	18.2
4)	% CA of GDP	1.3	1	-8.2	-6.5	-4.1	-2.6	-1.5	-1.0 [x]
5)	% unemployment	8.5	12.3	12.6	10.9	9.5	9.2	7.2	7.1

[i] real GDP growth - y.o.y.; [ii] end of year inflation; [iii] end of year change of nominal wages;
[iv] current account as a percent of GDP; n.a. — not available; x — CNB and NBH prediction
Source: Statistical Bulletin — a joint issue of Central Statistical Offices of CEFTA countries.

The two countries are considered to be the most successful in introducing a market economy among the East European countries in transition. They have implemented a successful macroeconomic stabilisation policy and attracted foreign investors. Cumulated foreign direct investment for the period from 1989 to 1998 was 8.4 billion US dollars for the Czech Republic and 16.4 billion US dollars for Hungary.[1] During the period the two countries had different exchange rate regimes. From the beginning of the transformation period Hungary chose crawling-peg exchange rate system, while the Czech Republic has chose a currency basket-peg exchange rate regime, which was abolished in May 1997. Since that time the Czech Republic has adopted a managed float exchange rate regime.

The rest of this paper is organised as follows. In Section 2 we briefly present the functional form of the equations for the Hungarian model as well as econometric estimates of the

[1] Source, EBRD.

parameters. In Section 3 we provide a comparative analysis between the two countries using the estimated models from this paper and Stavrev (1998), while Section 4 concludes.

2. Hungarian Model

In this section we will briefly describe the structure of the Hungarian model. We construct the model following closely the theoretical considerations explained in detail in Stavrev (1998). For a complete discussion of the theoretical basis of continuous-time macro models see Bergstrom (1990), Gandolfo (1981, 1993) and Gandolfo and Padoan (1984). It should be mentioned that both the Czech and Hungarian models are very similar in construction. We exploit this similarity in order to be able to compare the results about the two countries when using the models later in the simulation exercises.

2.1. Specification of the Equations

The model is an interdependent system of stochastic differential equations. To simplify, the disturbance terms are omitted. The symbol (^) refers to the partial equilibrium level, or the desired value of the variable, (^{e}) to its expectation, and *ln* to the natural logarithm. All parameters are assumed to be positive unless otherwise specified.

Consumption function

$$\mathrm{D}lnC = a_1 ln\left(\frac{\hat{C}}{C}\right) + a_2\, m2 \tag{1}$$

where

$$\hat{C} = g_1 Y \text{ where } g_1 \text{ is marginal propensity to consume} \tag{1.1}$$

C – real consumption[2]

m2 – proportional rate of change of money supply (M2)

Y – real gross domestic product

In equation (1) real aggregate consumption,[3] *C*, adjusts to its desired level, $\hat{C}$, which is given as the marginal propensity to consume applied to real domestic income. The second

[2] For a detailed specification of the data see Appendix 1.

term in this equation must capture the impact of the monetary variables, proxied by *m2*, on consumption. The idea is that nominal money balances play a buffer role in the private sector asset portfolio, allowing unexpected variations in income and expenditure.

Imports

$$D\ln Im = a_3 \ln\left(\frac{\hat{Im}}{Im}\right) + a_4 \ln\left(\frac{\hat{V}}{V}\right) \tag{2}$$

where

$$\hat{Im} = g_2 \left(\frac{P}{P_f Q}\right)^{\beta_1} (DK)^{b2} C^{b3} E^{b4} \tag{2.1}$$

$$\hat{V} = g_4 Y^e, \tag{2.2}$$

Im	– real imports
V	– stock of inventories in real terms
DK	– change of fixed capital stock in real terms
P_f	– foreign price level[4]
P	– domestic price level (CPI)
E	– real exports
Q	– nominal exchange rate

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[3] Precisely speaking, in equation (1) and in the following equations we define the rate of change in the left hand side variables as opposed to their real levels, but after the integration of the system (1) – (12) we will obtain the levels of the variables.

[4] For the estimation we use the price level in the rest of the world, which is constructed as a weighted average of US and German price levels as follows: $P_f = w*e_{DM\$}* P_{us} + (1-w)*P_{Ger}$ where *w* is the weight of the US dollar taken according to the definition given in Appendix 1 and $e_{DM\$}$ is the exchange rate of the US dollar with respect to the German mark. Thus, the price index for the rest of the world is expressed in German marks. We obtain income for the rest of the world in the same way.

Real imports defined in equation (2) are determined by two terms. First, they adjust to their desired value $\hat{\mathrm{Im}}$, which is a function of real exchange rate and consumption and investment expenditures. This specification connects demand for imports to total sales and takes into account the fact that some imported goods are included in exports. Second, imports are connected to the change in inventories. If inventories are less than their desired level, imports will increase. Hence, inventories are supposed to play a buffer role between supply and demand in the goods market.

Exports

$$D\ln E = a_5 \ln\left(\frac{\hat{E}}{E}\right) \tag{3}$$

where

$$\hat{E} = \gamma_3 \left(\frac{P}{P_f Q}\right)^{-\beta_5} Y_f^{\beta_6} \tag{3.1}$$

Y_f – real foreign income

Equation (3) defines the demand for real exports of goods and services. Their partial equilibrium level depends on real exchange rate and foreign income. The export equation in the Hungarian model differs from the one used in the Czech model. Taking into account the differences in the exchange rate systems — Hungary has a crawling-peg system and the Czech Republic for most of the sample period had a fixed exchange rate — we have decided to relate Hungarian exports to real exchange rate and foreign income.

Expected output

$$D\ln Y^e = x \ln\left(\frac{Y}{Y^e}\right) \tag{4}$$

Y^e – expected output

Equation (4) defines expected output. Expected output evolves according to an adaptive expectation mechanism and has two functions in the model. In addition to determining real output, it connects real output to the rest of the model by the presence of the second term in equation (5) below.

Output

$$\mathrm{D}\mathit{ln}Y = a_6\, ln\left(\frac{Y^e}{Y}\right) + a_7\, ln\left(\frac{\hat{V}}{V}\right) \tag{5}$$

where

$$\hat{V} = g_4 Y^e. \tag{5.1}$$

Real output is defined in equation (5). It adjusts to its desired level, which in this case is represented by expected income, and depends on the difference between the desired level of inventories and their actual level. It is assumed that producers have a desired ratio of inventories to expected output – g_4. Hence, they will increase output and imports when the desired inventories are bigger than the actual inventories.

Fixed capital formation

$$\mathrm{D}k = a_8 \{\left(\frac{D\hat{K}}{K}\right) - k\} + a_9\, m2 \tag{6}$$

where

$$D\hat{K} = g_5 Y^e \tag{6.1}$$

Equation (6) defines the development of the fixed capital stock. The proportional change of capital stock *k* adjusts to its desired level $\hat{k} = \left(\frac{D\hat{K}}{K}\right)$. The desired investment, $D\hat{K}$, is a function of expected income. As in the consumption function, the speed of the adjustment of *k* to its desired level is assumed to be an increasing function of *m2*. The idea is to use the percentage change in *M2* as a proxy for the credit conditions in the economy. It may seem more appropriate to use the interest rate in the above equation and incorporate it into the whole model, but we have decided not to include the interest rate for several reasons. It seems plausible to assume that, for countries in transition, the interest rate may not be the main factor affecting investment decisions of economic agents during the first stage of the transformation.

Domestic price level

$$\mathrm{D}\mathit{lnP} = a_{10}\, ln\left(\frac{\hat{P}}{P}\right) + a_{11}\, ln\left(\frac{M2}{M2_d}\right) \tag{7}$$

where

$$\hat{P} = g_6\, (P_f Q)^{b7} \left(\frac{W}{\mathrm{Pr}}\right)^{\beta_8} \tag{7.1}$$

$$M2_d = (PY)^{bmd} \quad \text{– money demand} \tag{7.2}$$

M2 – nominal stock of money supply

Pr – productivity

W – nominal wage

Domestic price level is defined in equation (7). In the first term domestic price level adjusts according to the difference between the desired and actual price level. The desired price level is assumed to depend on both domestic and foreign factors. The domestic cost factors are represented by the level of the nominal wage rate *W* and productivity, which is exogenously given. The foreign factor is represented by the foreign price level. The second term represents the monetary factor in determining domestic price level.

Wages

$$\mathrm{D}\mathit{lnW} = a_{12}\, ln\left(\frac{\hat{W}}{W}\right) \tag{8}$$

where

$$\hat{W} = g_7\, \mathrm{P}^{b9}\, e^{\lambda_1 t} \tag{8.1}$$

The nominal wage rate, equation (8), adjusts to a partial equilibrium level $\hat{W}$, which depends on the domestic price level and institutional factors (trade unions, etc.). Thus, it is assumed that the target nominal wage exceeds the level determined only by the domestic price level.

The institutional factors are captured by the trend term in the formula for the desired nominal wage.

Influence of the Balance of Payments on Money Supply

$$Dm2 = a_{13}\,(\hat{m}2 - m2) \tag{9}$$

where

$$\hat{m}2 = d_1\, ln\left(\frac{E}{g_8\,\mathrm{Im}}\right) - d_2\, Dln\left(\frac{P}{P_f Q}\right), \qquad \delta_1 <=> 0, \tag{9.1}$$

Equation (9) is a policy function and is supposed to describe the monetary authorities' adjustment of the percentage change of nominal money stock to its target value $\hat{m}2$. The first and the last terms are supposed to capture the balance-of-payments effects. The parameter g_8 can be interpreted as the ratio of exports to imports which the monetary authorities target to give the desired structure to the balance of payments. The second term in this equation represents the anti-inflationary target of the monetary policy, which in this case focuses on relative price stability. The d coefficients represent the different weights given to the different targets. Coefficient d_2 must be positive, while d_1 may be either positive or negative.

Capital Stock

$$DlnK = k \tag{10}$$

Money Supply

$$DlnM2 = m2 \tag{11}$$

Inventories

$$DV = Y + Im - E - C - DK \tag{12}$$

The last three equations in the model are definitions. Equations (10) and (11) help us to express the model as a system of 12 first order differential equations. Equation (12) defines the change in the real inventories as a residual term.

There are 12 equations and 12 endogenous variables in the model. The only exogenous variables in the model are time – t, productivity – Pr, foreign price level – P_f and foreign income – Y_f.

2.2. Econometric Results

We present the estimated equations for the Hungarian model below.[5] Standard errors are given in brackets. For simplicity the error terms are omitted.

$$DlnC = \underset{(0.14)}{0.39}\, ln\left(\frac{0.75Y}{C}\right) + \underset{(0.75)}{3.36}\, m2 \qquad (1')$$

$$DlnIm = \underset{(0.16)}{0.79}\, ln\left(\frac{\underset{(550.5)}{178.5}\left(\frac{P}{P_f Q}\right)^{\underset{(0.85)}{1.93}} DK^{\underset{(0.07)}{0.17}} C^{\underset{(0.23)}{0.32}} E^{0.25}}{\mathrm{Im}}\right) + \underset{(0.08)}{0.02}\, ln\left(\frac{1.05Y^e}{V}\right) \qquad (2')$$

$$DlnE = \underset{(0.1)}{0.36}\, ln\left(\frac{\underset{(0.45)}{2.41}\left(\frac{P}{P_f Q}\right)^{\underset{0.74}{2.22}} Y_f^{1}}{E}\right) \qquad (3')$$

$$DlnY = \underset{(0.12)}{0.75}\, ln\left(\frac{Y^e}{Y}\right) + \underset{(0.004)}{0.02}\, ln\left(\frac{1.05Y^e}{V}\right) \qquad (5')$$

$$Dk = \underset{(0.14)}{0.85}\left(\left(\frac{\underset{(0.04)}{0.14}Y^e}{K}\right) - k\right) + \underset{(0.04)}{0.25}\, m2 \qquad (6')$$

$$DlnP = \underset{(0.15)}{0.43}\, ln\left(\frac{\underset{(0.01)}{0.02}(P_f Q)^{\underset{(0.15)}{1.39}}\left(\frac{W}{\mathrm{Pr}}\right)^{\underset{(0.14)}{0.36}}}{P}\right) + \underset{(0.07)}{0.07}\, ln\left(\frac{M2}{(PY)^1}\right) \qquad (7')$$

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[5] Full description of the Czech model is given in Stavrev (1998). In Appendix 2 of this paper we present only the estimated equations of the model.

$$\mathrm{D}\mathit{lnW} = \underset{(0.22)}{1.14}\, \mathit{ln}\left(\frac{\underset{(1112.5)}{28454.5}\, P^{\underset{(0.04)}{0.14}} e^{\underset{(0.0048)}{0.04t}}}{W} \right) \tag{8'}$$

$$\mathrm{D}\mathit{m2} = \underset{(0.15)}{1.17}\ \{\underset{(0.003)}{0.02}\, \mathit{ln}\left(\frac{E}{\underset{(0.413)}{0.88}\, \mathrm{Im}} \right) - \underset{(0.26)}{0.77}\, \mathit{Dln}\left(\frac{P}{P_f Q} \right) - \mathit{m2}\}, \tag{9'}$$

In this model we have estimated 13 adjustment speeds and buffer stock effects (the a -parameters). Only two of them, the buffer stock coefficient a_4 capturing the effect of inventories on real imports in equation (2) and a_{11} reflecting the effect of money supply on the price level in equation (11), are not significant at 5% level of significance. In addition to the adjustment speed parameters we have 21 other parameters: constants, elasticities, policy parameters and a trend term (g, b, d and l correspondingly). Only one of them, b_8 capturing the effect of productivity on price level, is not significant at 5% significance level. We have estimated 34 parameters and only 3 of them are not significant at 5% level of significance.

We will discuss several important factors in the estimation of some of the equations in the Hungarian model. For the period from the first quarter of 1991 to the fourth quarter of 1995 there are no quarterly data on consumption and GDP for the Hungarian economy. There are, however, quarterly data for exports, imports and fixed capital. In order to estimate equations (1), (2) and (5) we construct for the period from first quarter of 1991 to fourth quarter of 1995 quarterly data for consumption and GDP according to the explanations given in Appendix 1. Then we obtain the change in inventories as a residual term. In addition to this equations (1) and (5) are estimated using the same structure of the equations as in the quarterly model with annual data for the period from 1988 till 1997.

We conducted stability and sensitivity analyses exactly as in the Czech model. It should be mentioned that all real parts of the characteristic roots of the parameter matrix are negative, which indicates that the Hungarian model is locally stable.[6]

[6] For extended stability and sensitivity analysis of the Czech macro model see Stavrev (1998).

3. Comparative Study of the Czech Republic and Hungary Based on the Model Simulations

The results of the simulations present in this section are given as deviations from the base solution. We consider the effect of the different simulations on the following variables: inflation rate *DlnP*, rate of growth of real consumption *DlnC*, rate of growth of fixed capital *DlnK*, rate of growth of output *DlnY*, rate of growth of real wage rate *Dln(W/P)*, and the balance of goods and services *TB*, the last term defined as the ratio of the value of exports to the value of imports — *Dln(E/Im)*. We will speak about improvement in inflation when *DlnP* decreases, but improvement in output for example is connected with an increase in *DlnY*. The same is true for the remaining variables.

3.1. Simulations with Macro-Econometric Models and Lucas Critique

Before explaining the simulations' results we will discuss Lucas critique (Lucas, [1976]) and its implications for the exercises we are using in this paper to evaluate alternative policies. In what follows we will briefly present some of the most relevant arguments which have been presented in the literature in defence of simulation analysis. It is by no means an attempt to reject Lucas point, but rather to show that in some cases it is possible to use simulation exercises for different policy evaluations.[7] Moreover this method is even less vulnerable to Lucas critique when one tests the properties of a macro-econometric model.

According to Gandolfo and Padoan (1984) simulation exercises may be classified four different types: Type 1 — exogenous variables are assumed to follow a different path from the actual one; Type 2 — endogenous variables, other than policy variables, are chosen to follow a given time path; Type 3 — there are policy changes which are uncertain and insincere, meaning that policy makers either do not specify their present and future behaviour or the policy they announce might be different from the one actually implemented; Type 4 — the policy change is sincere and once and for all, implying that the economic agents have time to adjust their behaviour to the new policy regime.

Sims (1982) has pointed out that Lucas critique fully applies only to simulations of the fourth type because economic agents have enough time and information to adjust their behaviour to the new policy regime. Such events rarely happen in the real world and as an example we may give the end of the Bretton-Wood system of exchange rates or the fixed exchange rate system for the Czech Republic. Sims' argument that "permanent shifts in policy regime are by definition rare events" does not overcome the difficulty of dealing with a Type 4 policy change.

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[7] For a more detailed discussion on the matter see Sims (1982) and Klein (1983).

Another argument, which seems more effective in solving this problem, is one suggested by Jonson and Trevor (1981) that in the real world neither the policy maker nor the economic agents really know how the system as a whole will react to the implementation of a new policy rule. Consequently, it is a useful exercise, provided in-sample simulations are carried out, to “rerun the history”, in order to obtain additional information on the behaviour of the system (in the spirit of Vines, Miciejowsky and Meade[1983]).

If the policy makers do not specify in detail their planned strategy, the economic agents will have difficulties trying to adjust their behaviour. It appears that Lucas critique is not applicable when Type 3 policy rules are simulated. Moreover, policy makers quite often do not have a completely clear idea of what their policy should be and, therefore, they will try to define it by a trial-and-error process. It is clear then that uncertainty and insincerity might arise not only as an explicit choice of the policy makers but from the fact that they need time to work out their own way of applying the policy. Consequently, even if economic agents have enough time to adjust to a given policy, this will change simply because the policy makers will react to the system’s response.

With respect to Type 1 simulations, Mishkin (1979) argues that shocked values of exogenous variables should be consistent with the time series model of historical values if simulation results are reliable. This argument applies also when Type 2 simulations are carried out.

3.2. Anti-inflationary Policies

We believe that this type of policy simulations is of special importance for countries in transition. After abandoning the system of command price-setting, all countries from the formerly centrally planned economies experienced an initial period of high inflation. Countries like the Czech Republic and Hungary managed to stop the inflation spiral and achieved during the last four years an inflation of about 8.5 to 10% in the case of the Czech Republic and 18 to 22% in the case of Hungary.

There are different hypotheses among economists about the causes of inflation in the transition countries. Some economists argue that inflation was fuelled by the usually large initial devaluation in the currencies of these countries. Other economists support the view that price distortion (completely wrong relative prices inherited from the past) is the driving force of inflation. We believe that in addition to the above reasons money supply and wages may be to a great extent responsible for the relatively high inflation in the transition countries. With the models we have built for the Czech Republic and Hungary we can simulate the effect on inflation only of money supply and wages.

3.2.1. The Effect of Money Supply on Inflation

In order to study the effect of money supply on inflation we have used the following scheme. The estimated equation about the monetary authorities' reaction function in the two models was replaced by the following one:

$$Dm2 = a_{13}(m2_t^* - m2) \tag{13}$$

where $m2^*_t$ is the "target growth" of M2 prescribed by the policy makers. For the simulation exercises we assume that money supply grows in all four quarters of a particular year with the same speed. The values of the growth of the money supply for the four quarters of a particular year are chosen in such a way as to ensure a given yearly growth rate of the money supply. The simulation period is from the first quarter of 1994 to the fourth quarter of 1997. The actual yearly growth rates of money supply for the simulation period are $m2^{CR}_{A,t}$ = {20.9, 18.8, 9.2, 10.1} and $m2^{H}_{A,t}$ = {13.6, 18.4, 21.2, 22.9} for the Czech Republic and Hungary respectively.[8] For our simulations we have chosen quarterly growth rates of the money supply of the two countries so as to achieve for the simulation period a cumulative growth rate of money supply which is 5 percentage points lower than the cumulative growth rate in the basic solution for both countries.

The results of these simulations are given in Appendix 4. The simulations given there are produced using the Hungarian model. The results in the 12 figures in Appendix 4 represent the difference between the target and basic solution. The impact of this policy simulation is given on Figures A4.1 to A4.6. From Figure A4.1 we see that a 5% decrease in the growth rate of money supply has decreased the inflation rate by 0.5%. Lowering the rate of growth of money supply has a relatively strong impact on the real variables. Rate of growth of real consumption to the end of the simulation period falls by 0.18%. It is easy to understand this fact if we look at equation (1'). The effect on money supply is captured by the second term and the coefficient there is quite high. As is mentioned above, the role of this term is to capture the influence of wealth on consumption. There was a large privatisation in transition countries which could be considered one of the sources of wealth increase. It is then possible that consumers used this in order to increase their consumption. Capital stock is the least affected among the real variables. The purpose of second term in capital formation equation (6') is to capture the effect of the credit conditions on investment. It may be the case that market agents in transition countries will continue their investment plans even under tougher investment conditions. One explanation is that they a expect higher return on new productive capital because of the existence of a highly qualified and relatively cheap work force. Real wages grow, but at a decreasing speed. The effect of this policy on the trade balance is positive and at the end of the simulation period the current account gap is decreased by 0.30%.

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[8] The data are in percents.

3.2.2. The Effect of Wages on Inflation

In order to evaluate the effect of wages on the economy we replace the equation for nominal wages in the Hungarian the Czech model with the following one:

$$D \ln W = \lambda_t , \tag{14}$$

where *t*, stays for quarters. We have assumed that through out the simulation exercise the rate of growth of nominal wages will be kept constant for each particular year. The actual growth rates of the average nominal wages for the simulation period in the Czech Republic and Hungary are $\lambda_{A,t}^{CR}$ = {17.8, 19.1, 16.8, 8} and $\lambda_{A,t}^{H}$ = {22.5, 15.2, 17.5, 24} correspondingly. To study the effect of a wage decrease on inflation we have chosen l_t so as to obtain cumulative growth rate of wages 5% below the one of the basic solution for both countries.

The impact of this policy simulation on macroeconomic variables is present in Appendix 4 — Figures A4.7 to A4.12. Lower growth of wages decreases inflation. Since nominal wage decreases slower than the price level (see the value of the coefficient b_8) real wage growths. At the beginning of the simulation period all real variables grow at a progressively declining speed, and later decrease. As in the previous case the effect on capital stock is smaller. Trade balance experiences a short period of improvement and after that a continuous deterioration.

Under both anti-inflationary policy scenarios we have obtained the goal of lower inflation. Money supply and wages have a comparable (in magnitude) effect on inflation developments. The effect of money supply on the real variables, however, is stronger than the effect of nominal wages.

3.3. Excluding Foreign Prices from Wage Indexation

In this simulation we exclude imported inflation from the wage indexation mechanism captured in nominal wage equations for the Czech and Hungarian models correspondingly. In the new version of the wage equations we link nominal wages to the following price index, which is corrected for foreign inflation:

$$P_c = \frac{P}{P_f^{b_6}} . \tag{15}$$

The impact of this policy simulation on the macroeconomic variables is described in Appendix 5 — Figures A5.1 to A5.6.[9] Lower wage indexation results in lower than baseline inflation. It improves on average by 0.25% per quarter. Inflation is lower through the whole simulation period, though the major effect is in the first two years and then we observe converging to the base line solution. A lower inflation rate under this scenario is obtained at the cost of a lower real wage, which after two years starts returning to the control solution. The average lost in real wage is around 0.12% per quarter. As a result of this, however, we note a slight positive impact on real output and capital formation, especially during the first two years. This increase in real output is export led. As a result of lower inflation we can notice an improvement in competitiveness and thus an increase in real exports, which in turn leads to improvement in real output at the beginning of the period. We obtain initial strong improvement in balance of goods and services, which towards the end of the simulation period deteriorates. The impact on real consumption is very low and it remains stable through the simulation period. We record two different effects on consumption (consumption depends on output and money supply growth; see equations for real consumption for both models: on one side positive effect of output and on the other side negative effect of money supply growth, which is lower than the baseline in this simulation.

3.4. The Impact of Wage Adjustment

In this policy simulation we study the impact of the speed of adjustment of wages on the main macroeconomic variables specified at the beginning of Section 3. In order to do so we replace the estimated speed of adjustment coefficient in the models, a_{12}, which is around one quarter for both economies with speed of adjustment of one year. The results of the simulations with the Czech model are given in Appendix 6 — Figures A6.1 to A6.6.

As in the previous case we note an improvement in inflation performance at the beginning of the simulation period and deterioration in the real wage rate. Cumulative gain in inflation at the end of the first year is around 1% and cumulative loss in real wages is around 0.6%. The loss in real wages in this exercise is determined by the low adjustment of nominal wages towards its target value. In the previous exercise the reason for the lower real wage was the lower target of nominal wages, which did not account for the impact of foreign prices on domestic inflation and thus wages were indexed at a lower speed. The effect on real output, however, comes through the same transmission mechanism. Lower inflation supports higher growth of real output through higher real exports. Improvement in the balance of goods and services is greater at the beginning of the period and later on deteriorates as a result of the consequent increase in inflation and relative loss of competitiveness.

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[9] In these simulations we use the Czech model. The response of the macro variables obtained from the Hungarian model is similar.

3.5. The Impact of Price and Wage Freeze

In this exercise we study the effect of both price and nominal wage rigidities on the behaviour of the main macroeconomic variables. The results for the Czech model are given in Appendix 7.

In this exercise we have three stages. During the first stage, which includes the first two quarters of the simulation period, we set to zero the rate of growth of both prices and nominal wages. During the second stage, which includes the next two quarters, domestic prices rise at the same speed as foreign prices, but nominal wages are kept constant. During the third stage the model is set back to its estimated structure. This exercise is useful since it could induce some economic insights about the evolution of the main macroeconomic variables following a sequence of price and wage freezes in the transition economies resulting from price deregulation and wage bargaining with trade unions.

Under this policy we obtain a substantial decrease in inflation during the first year, but at the beginning of the second year inflation is already higher than the control solution, remaining on average 0.05% higher than the baseline scenario until the end of the period. At the beginning of the period we note lower real wages than the baseline, followed by higher real wages almost until the end of the simulations. The explanation about the existence of higher real wages under this policy is that for most of the simulation interval (except for the first year) wage formation is unchanged. This means that during the first two stages the discrepancy between the actual and the desired level of the nominal wages rises considerably. Then in the third phase, when the original mechanism operates, the growth rate of nominal wages exceeds the growth rate of prices in the quarters immediately following the end of the second stage, causing nominal wages to overshoot the baseline solution. This fact, in turn, leads to acceleration of the wage-price spiral and as a result we obtain higher inflation. Substantial improvement in competitiveness at the beginning leads to higher exports and thus higher output for the first one and a half years. Inflation deterioration later on has a negative impact on exports and through them on output as well.

3.6. Effectiveness of Monetary and Fiscal Policies

The effect of monetary and fiscal policies is studied using the framework described in Appendix 3 below. We investigate the stability of both models under the two scenarios presented there. Our criterion about the stability of the models is the sign of the real part of the characteristic roots. A positive real part indicates an explosive solution. However, the magnitude of the positive real part is important as well since relatively small positive values, even though showing instability, allow us to use the model for policy simulations.

We calculate the characteristic roots for each of the two models under the two scenarios and compare them with the values obtained solving the initial system of equations without the introduction of fiscal policy rules. Both scenarios described in Appendix 3 have a stabilising effect. In the case of the Czech Republic for “low taxation” policy in Scenario 1 we obtain a system with no positive real part of the characteristic roots. As is mentioned in Section 2 of this chapter the Hungarian model is locally stable. The introduction of both fiscal policy scenarios makes the model even more stable.

4. Conclusions

The results of the policy simulations performed in this paper proved to be useful instrument in understanding the specificity of the macroeconomic developments in the East European transition countries. We think that an important contribution of this work is its attempt to analyse ongoing economic processes in these countries in a dynamic framework using continuous-time macro models.

The main message of the anti-inflationary simulations is that it is possible with appropriate monetary policy to achieve acceptable inflation in the countries undergoing transformation. An important result is that for both countries a considerable reduction of money supply growth has a relatively large negative impact on consumption and output. Thus in the short to medium term, inflation behaviour does have an impact on the real variables if one takes into account the monetary links present in the models through consumption and capital formation equations. In the long term, however, when the model reaches its steady state, the growth rate of the real variables is related to the growth rate of the exogenous variables only.

Nominal wages and money supply have a comparable impact on inflation. Policy exercises performed with different wage indexation schemes and different speeds of adjustment of wages show that the development of nominal wages has an important impact on inflation development and, through competitiveness, on exports and output as well.

Policy simulations with a consecutive freeze of prices and wages as a result of a delay in price liberalisation and trade union bargaining leads to higher inflation, lower output and a worse balance of goods and services in the future. And generally leads to cycles in the behaviour of the main macroeconomic variables.

Last, but not least, the simulation results showed that the mix of fiscal and monetary policies has not been optimally used by the authorities in the transition countries of Eastern Europe. For both countries we find that appropriately defined fiscal policy feedback rules have a stabilising effect on macroeconomic variables.

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Appendix 1. Data Description

Sources of data

CSOH	Central Statistical Office of Hungary
NBH	National Bank of Hungary
OECD	OECD Main indicators

Definition of series

We use quarterly observations for the period from the first quarter of 1991 to the fourth quarter of 1997, and the series are defined as follows:

C *Real consumption*

Quarterly data for consumption for the period from the first quarter of 1991 to the fourth quarter of 1995 were constructed using quarterly data on retail sales in Hungary. The following formula was used:

$$C_{t,q} = \frac{RSI_{t,q}}{\sum RSI_{t,q}} C_t ,$$

where the index t stays for years and t = 1991,..1995, RSI is a retail sales index and C_t is annual consumption. From the first quarter of 1996 to the fourth quarter of 1997 quarterly data for consumption published by CSOH were used.

Y *Real income or output*

Quarterly data for consumption for the period from the first quarter of 1991 to the fourth quarter of 1995 were constructed using quarterly data on retail sales in Hungary. The following formula was used:

$$Y_{t,q} = \frac{IPI_{t,q} + CPI_{t,q} + API_{t,q}}{\sum IPI_{t,q} + \sum CPI_{t,q} + \sum API_{t,q}} Y_t ,$$

where the index t stays for years and t = 1991,..1995, IPI is an industrial production index, CPI is a construction production index, API is an agriculture production index and Y_t is yearly GDP. From the first quarter of 1996 to the fourth quarter of 1997 quarterly GDP data published by CSOH were used.

K *Real fixed capital formation*

Gross domestic fixed capital formation at constant prices cumulated on a base stock of 1000 billion Forints in the end of 1990. Source: CSOH

E *Real exports*

Exports of goods and services at constant prices. Source: CSOH

Im *Real imports*

Imports of goods and services at constant prices. Source: CSOH

P *Domestic price level*

Consumer Price Index. Source: CSOH

M2 *Volume of money*

Nominal stock of the money supply (M2 aggregate). Source: NBH

Q *Nominal exchange rate*

Nominal exchange rate basket. Until December 8, 1991 based on a composition of currencies for external trade of goods in the previous year; from December 9, 1991 as 50–50% of US dollar and ECU; from August 2, 1993 as 50–50% of US dollar and Deutsche mark; from May 16, 1994 as 70–30% of ECU and US dollar; from January 1, 1997 as 70%-30% of DEM and US dollar.

As of March 16 1995, the earlier system of step devaluation was replaced by pre-announced crawling peg adjustments. Until the end of June the forint was devalued by 0.06% daily. In the second half of 1995 the daily rate of crawl was 0.042%. The rate of daily devaluation between January 1, 1996 and March 31, 1997 was 0.04% , and since April 1, 1997 it has decreased to a daily 0.036%. From August 15, 1997 the rate of daily devaluation has further decreased to 0.033%. *Source:* NBH

V *Inventories*

Value of the physical increase in stocks at constant prices cumulated on a base stock of 1500 million forints at the end of 1990 (DV = Y + Im - K - E - C).

W *Wage rate*

Nominal average wage in Hungary. Source: NBH

Pr *Productivity*

Value added per worker in the industrial sector at constant prices. Source: CSOH

P_f *Foreign price level*

This index was built by weighting consumer price indexes of the USA and Germany by 0.35 and 0.65 respectively. Source: OECD

Appendix 2. The Czech Model

We present the estimated equations below. Standard errors are given in brackets. In the interest of simplicity the error terms are omitted.

$$DlnC = \underset{(0.17)}{1.39}\, ln\left(\frac{\underset{(0.022)}{0.72}\, Y}{C}\right) + \underset{(0.94)}{2.20}\, m2 \qquad \text{(A2.1)}$$

$$DlnIm = \underset{(0.078)}{1.87}\, ln\left(\frac{\underset{(0.087)}{1.35}\left(\frac{P}{P_f}\right)^{\underset{(0.55)}{1.26}} DK^{\underset{(0.043)}{0.41}} C^{\underset{(0.116)}{0.76}} E^{\underset{(0.12)}{-0.17}}}{\mathrm{Im}}\right) + \underset{(0.28)}{1.07}\, ln\left(\frac{\underset{(0.12)}{0.95}\, Y^e}{V}\right) \qquad \text{(A2.2)}$$

$$DlnE = \underset{(0.254)}{1.3}\, ln\left(\frac{\underset{(64.15)}{187.61}\, P^{\underset{(0.12)}{-0.35}} e^{\underset{(0.0155)}{0.042}\, t}}{E}\right) \qquad \text{(A2.3)}$$

$$DlnY = \underset{(0.265)}{1.96}\, ln\left(\frac{Y^e}{Y}\right) + \underset{(0.132)}{0.21}\, ln\left(\frac{\underset{(0.12)}{0.95}\, Y^e}{V}\right) \qquad \text{(A2.4)}$$

$$Dk = \underset{(0.186)}{1.49}\left(\left(\frac{\underset{(0.051)}{0.264}\, Y^e}{K}\right) - k\right) + \underset{(0.099)}{0.243}\, m2 \qquad \text{(A2.5)}$$

$$DlnP = \underset{(0.072)}{0.143}\, ln\left(\frac{\underset{(0.77)}{0.63}\, P_f^1\left(\frac{W}{\mathrm{Pr}}\right)^{\underset{(0.361)}{0.175}}}{P}\right) + \underset{(0.082)}{0.168}\, ln\left(\frac{M2}{(PY)^1}\right) \qquad \text{(A2.6)}$$

$$DlnW = \underset{(0.249)}{1.06}\, ln\left(\frac{\underset{(603.82)}{5663.25}\, P^{\underset{(0.179)}{0.209}} e^{\underset{(0.0048)}{0.039t}}}{W}\right) \qquad \text{(A2.7)}$$

$$Dm2 = \underset{(0.229)}{1.374}\left\{\underset{(0.079)}{0.068}\, ln\left(\frac{E}{\underset{(0.413)}{0.47}\,\mathrm{Im}}\right) - \underset{(0.992)}{0.79}\, Dln\left(\frac{P}{P_f}\right) - m2\right\}, \qquad \text{(A2.8)}$$

Appendix 3. Effectiveness of Monetary and Fiscal Policies

Scenario 1

In this scenario the following tax rule is introduced:

$$D\ln T = \alpha_{15} \ln\left(\frac{g_T PY}{T}\right), \tag{A3.1}$$

where T is the total tax bill, α_{15} is the speed of adjustment of taxes and g_T is the tax rate applied by the government. This coefficient may reflect the different speed at which the authorities collect taxes. The term PY is nominal GDP. Then we replace real consumption equation in both models with the following three equations:

$$D\ln C_p = \alpha_1 \ln\left(\frac{g_1(Y - T/P)}{C_p}\right), \tag{A3.2}$$

where $C_{p.}$ is real private consumption.

$$D\ln C_g = \alpha_{16} \ln\left(\frac{gY}{C_g}\right), \tag{A3.3}$$

where C_g is real government consumption and g is the government's propensity to consume taken as an exogenous variable in this scenario. Total consumption C is given by:

$$C = C_p + C_g \tag{A3.4}$$

After that we solve the system consisting of equations (A3.1), (A3.2), (A3.3), (A3.4) and the rest of the equations of the original system (without real consumption equation) for both models for different values of the policy parameters g_T and g in the range {0.15 – 0.45} and {0.18 – 0.24} and speed of adjustment of taxes to their target value – α_{15} about one year. We call a policy "a low taxation policy" when the tax rate parameter $g_T \in$ {0.15 – 0.34} and "a high taxation policy" when $g_T \in$ {0.35 – 0.45}.

4.5.2. Scenario 2

In this subsection, a more sophisticated fiscal policy feedback relation is introduced. In both the Czech and Hungarian models we implicitly assumed that fiscal policy was, in a sense, neutral and that monetary policy was achieved by reacting to balance of payment variations and the deviation of domestic inflation from foreign inflation. Here we assume that taxation rates and government expenditure vary in response to deviations in output from its steady-state path. The fiscal policy feedback relation can be introduced mathematically by defining *T* as follows:

$$T = \frac{g_1}{g + g_1(1-t)}, \tag{A3.5}$$

where *g* is the partial equilibrium ratio of current government expenditure to national income and *t* is the taxation rate. We replace real consumption equation in both models with the following one

$$\mathrm{D}lnC = a_1 ln\left(\frac{\hat{C}}{TC}\right) + a_2\, m2. \tag{A3.6}$$

A neutral fiscal policy is obtained if *T* = 1, in which case equation (A3.6) reduces to the estimated real consumption equation in both models.

Using equation (A3.5) equation (A3.6) can be rewritten as follows:

$$\mathrm{D}lnC = a_1 ln\left(\frac{gY + g_1(1-t)(Y - T/P)}{C}\right) + a_2\, m2. \tag{A3.7}$$

As in the previous case, we introduce the fiscal policy feedback relation into the model by defining *T* in the following way:

$$\mathrm{D}lnT = a_{15} ln\left(\frac{(Y/Y^* e^{l_y t})^{b_{20}}}{T}\right), \tag{A3.8}$$

where $Y^* e^{l_y t}$ is the long run equilibrium growth path of output, and a_{15} and b_{20} are policy parameters. The parameter b_{20} measures the strength of the feedback. Equation (A3.8) indicates that *lnT* depends with an exponentially distributed time lag on the logarithm of the ratio of real output to its long-run equilibrium level. It also implies that if *g* is constant, the taxation rate will converge to a level which increases as the proportional excess of real output over its long-run level increases. If t is constant then government propensity to spend will converge to a level which is lower the greater is the proportional excess of real output over its long-run equilibrium level. To determine plausible values for this parameter we use equations (A3.7) and (A3.8). If $b_{20} > 1$, then from equation (A3.8) it follows that an increase in output will allow for an increase in *T*. In order to increase *T* the government should increase taxes and/or decrease spending. It follows from equation (A3.7) that the partial equilibrium level of aggregate consumption will be less than it would have been if output had not increased. It is thus unrealistic to assume a value of this coefficient much greater than 1. The reciprocal of the coefficient a_{15} is the mean of the distributed time lag with which *T* responds to changes in output from its steady-state level. For example $a_{15} = 1$ means an adjustment speed of one quarter.

The new system consisting of the original one plus equation (A3.8) is linearised around the equilibrium point, and the impact on the stability of the system for different values of the policy parameters is investigated.

Appendix 4. Anti-inflationary Policies

A4.1. The Effect of Money Supply on Inflation

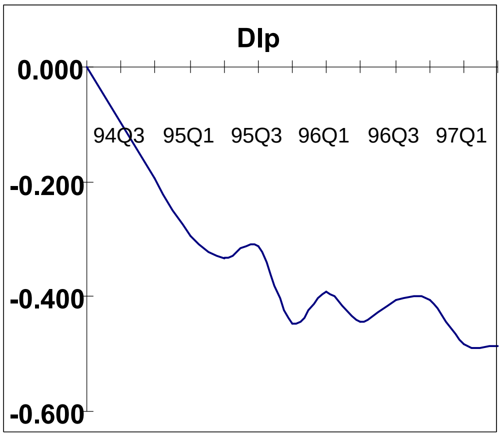

Figure A4.1 — Effect on Prices

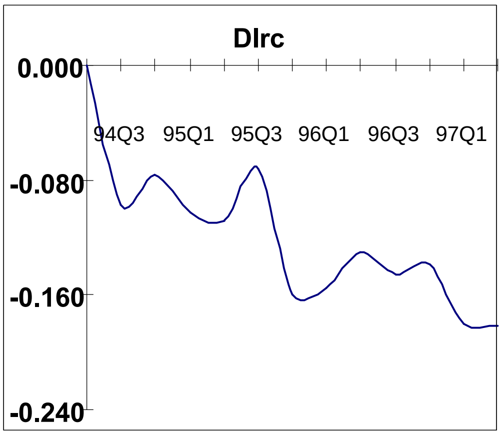

Figure A4.2 — Effect on Consumption

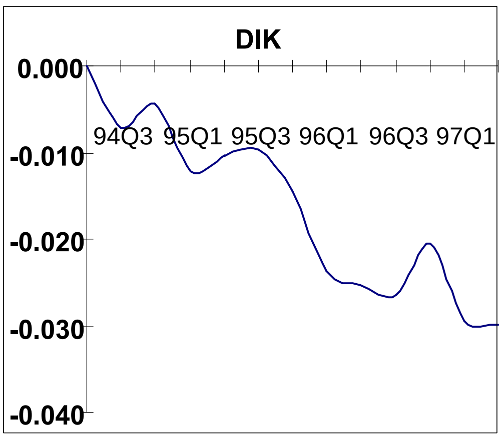

Figure A4.3 — Effect on Capital Stock

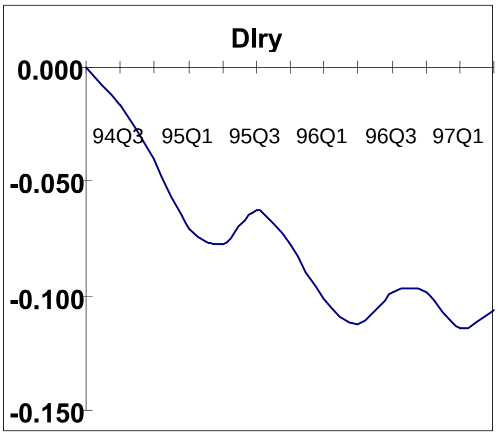

Figure A4.4 — Effect on Output

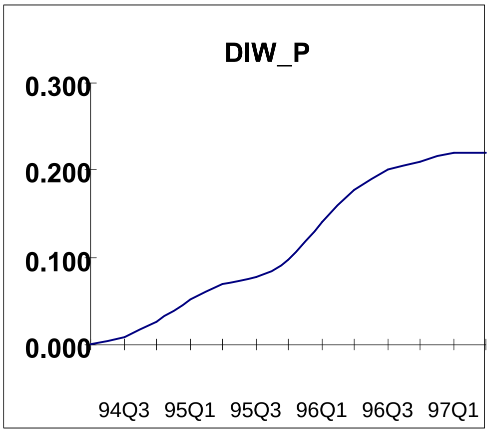

Figure A4.5 — Effect on Real Wage

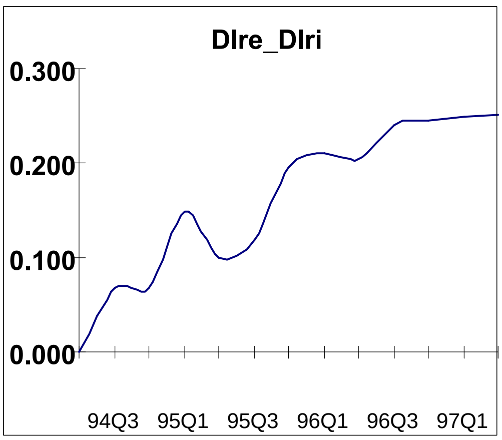

Figure A4.6 — Effect on Trade Balance

A4.2. The Effect of Wages on Inflation

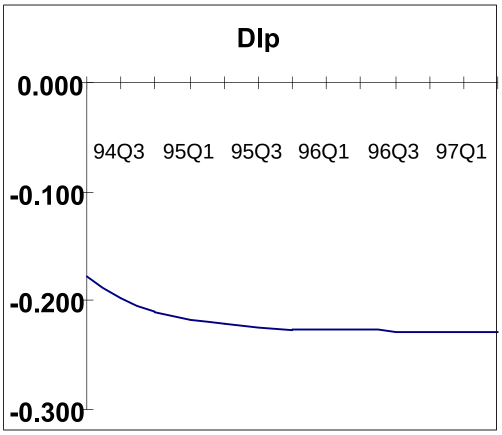

Figure A4.7 — Effect on Prices

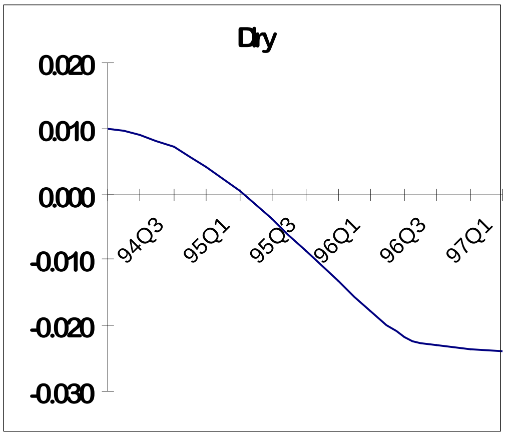

Figure A4.10 — Effect on Output

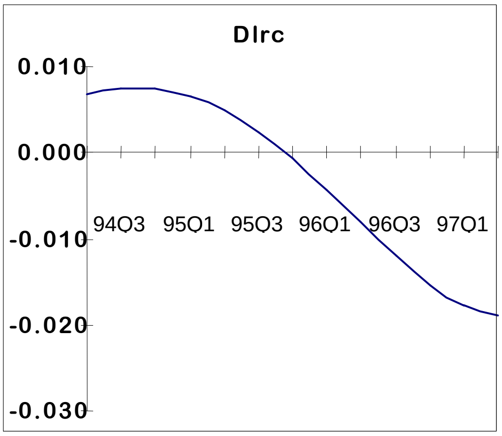

Figure A4.8 — Effect on Consumption

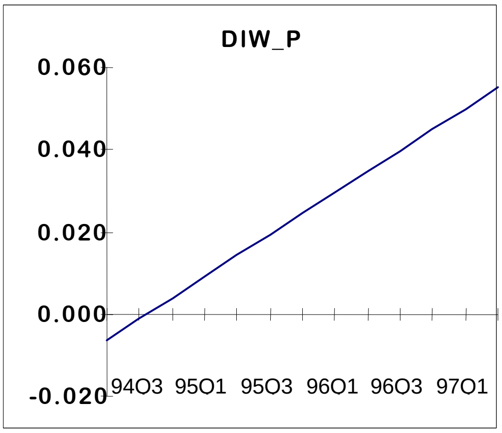

Figure A4.11 — Effect on Real Wage

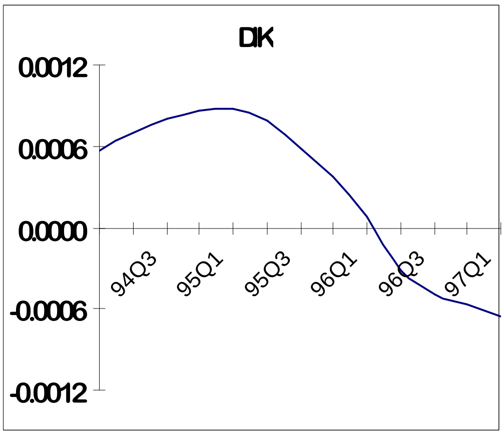

Figure A4.9 — Effect on Capital Stock

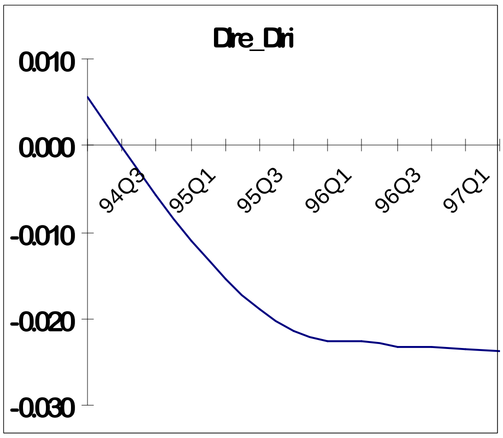

Figure A4.12 — Effect on Trade Balance

Appendix 5. Excluding Foreign Prices from Wage Indexation

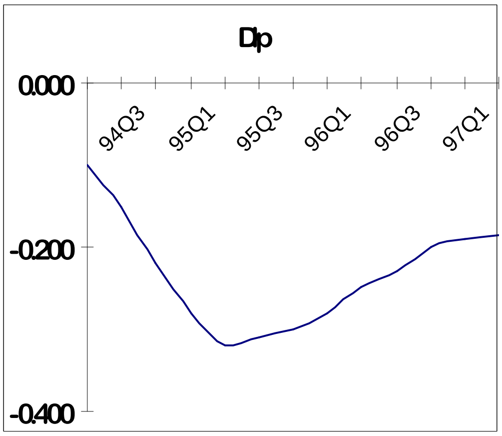

Figure A5.1 — Effect on Prices

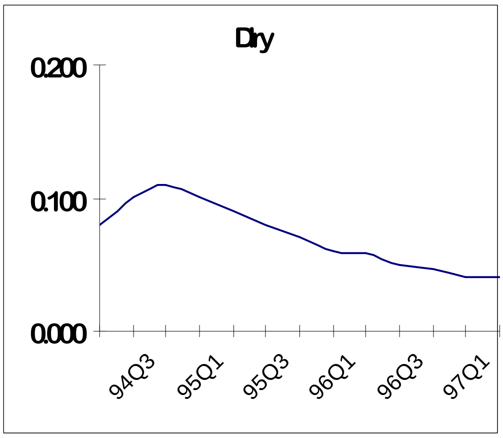

Figure A5.4 — Effect on Output

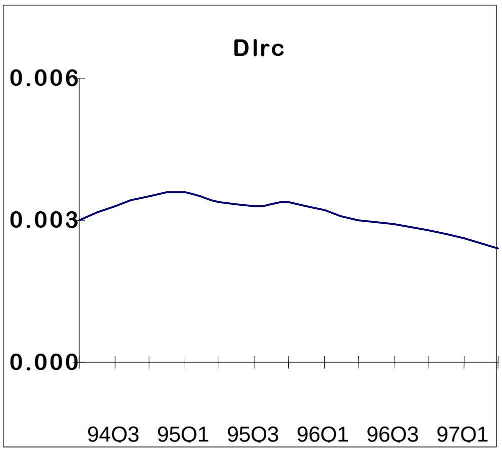

Figure A5.2 — Effect on Consumption

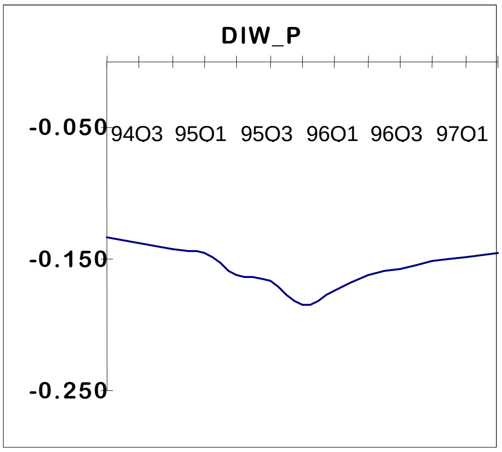

Figure A5.5 — Effect on Real Wage

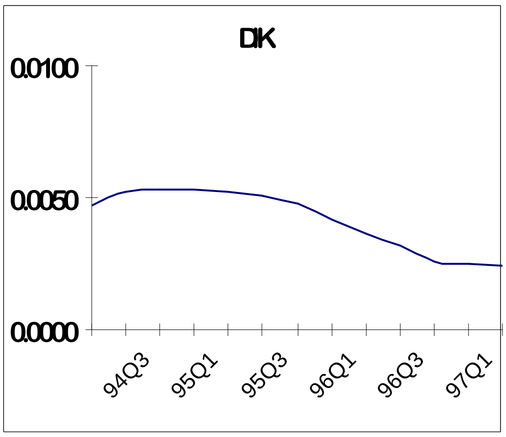

Figure A5.3 — Effect on Capital Stock

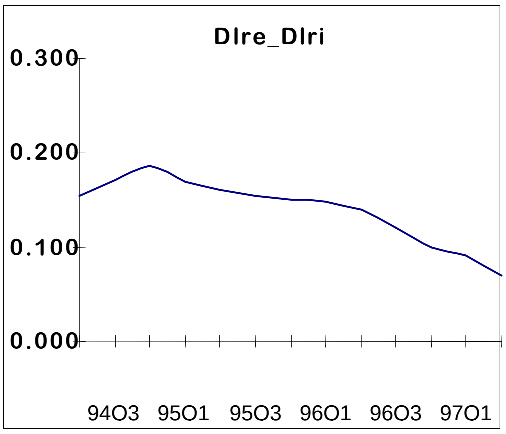

Figure A5.6 — Effect on Trade Balance

Appendix 6. The Impact of Wage Adjustment

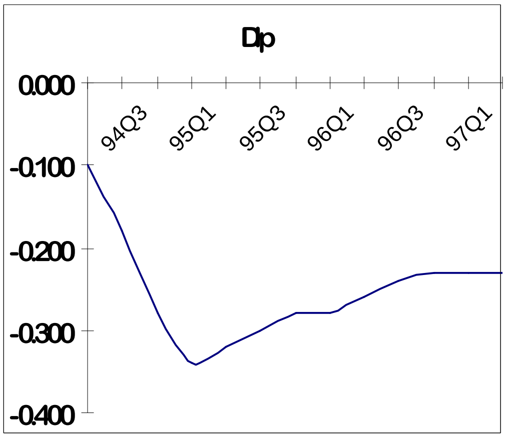

Figure A6.1 — Effect on Prices

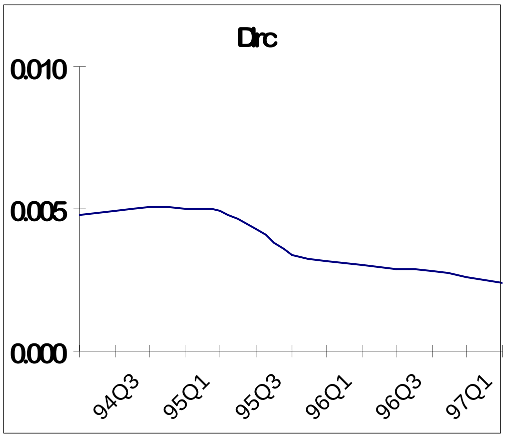

Figure A6.2 — Effect on Consumption

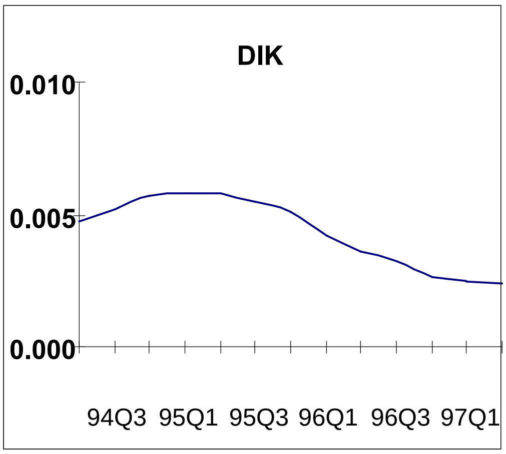

Figure A6.3 — Effect on Capital Stock

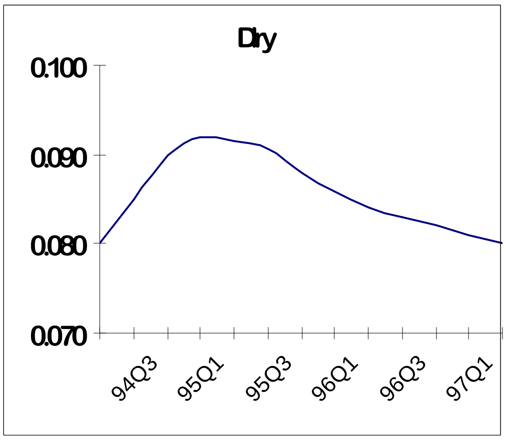

Figure A6.4 — Effect on Output

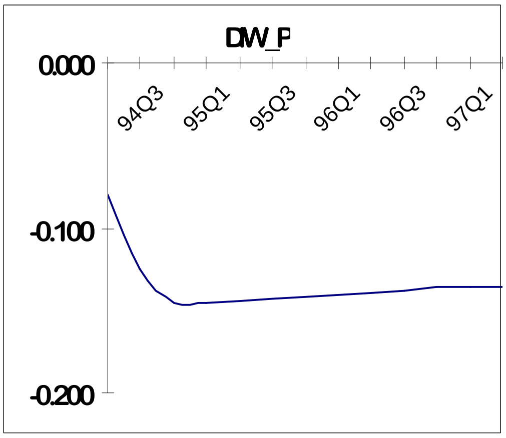

Figure A6.5 — Effect on Real Wage

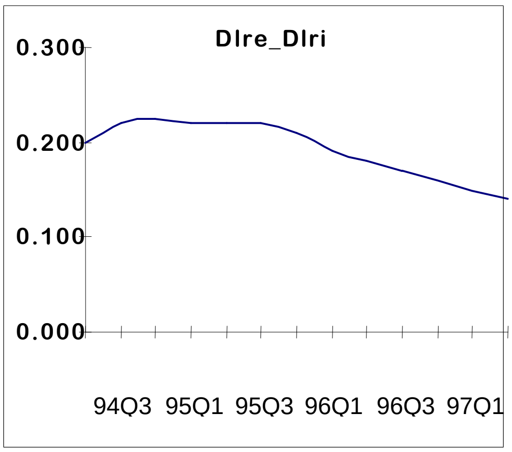

Figure A6.6 — Effect on Trade Balance

Appendix 7. The Impact of Price and Wage Freeze

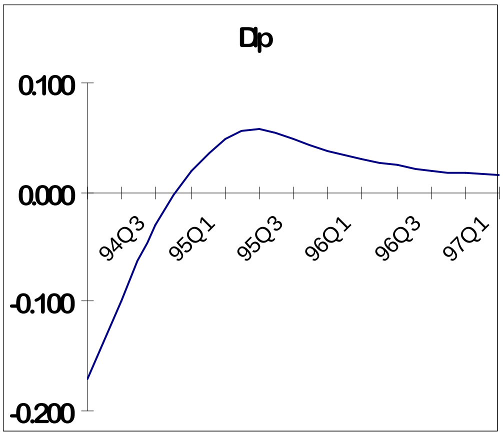

Figure A7.1 — Effect on Prices

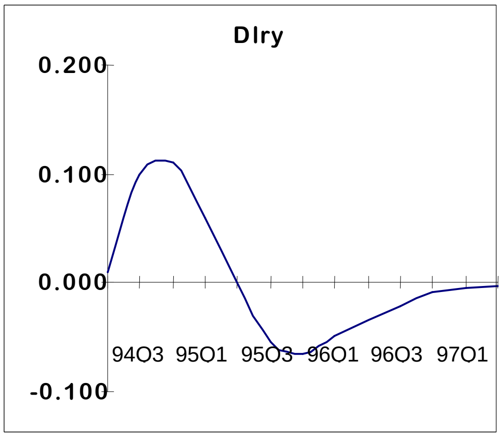

Figure A7.4 — Effect on Output

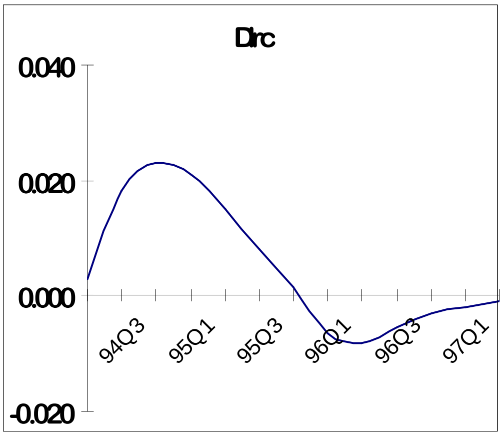

Figure A7.2 — Effect on Consumption

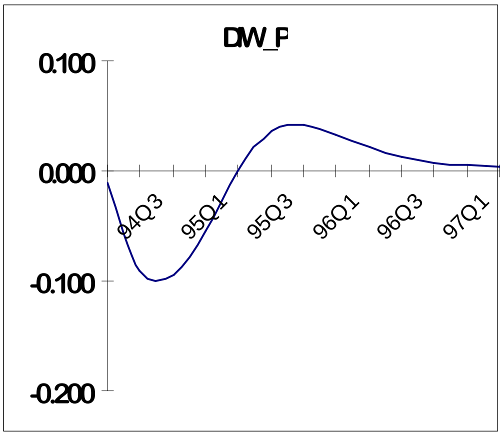

Figure A7.5 — Effect on Real Wage

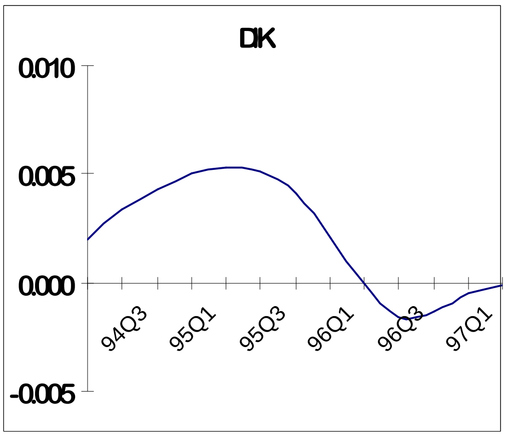

Figure A7.3 — Effect on Capital Stock

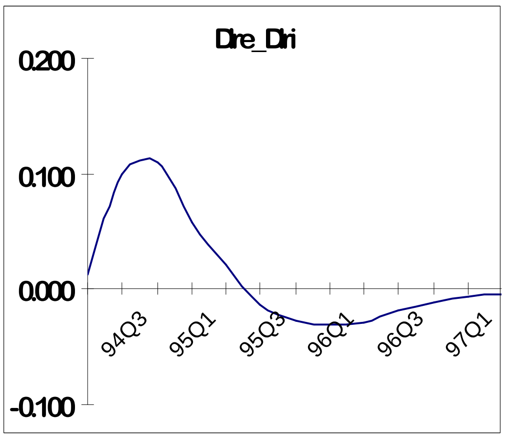

Figure A7.6 — Effect on Trade Balance

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